

CHAPTER 18

ORGANIZING AND INTEGRATING SYSTEM DEVELOPMENT

18.1 INTEGRATED DEVELOPMENT

DoD has, for years, required that system designs be integrated to balance the conflicting pressure of competing requirements such as performance, cost, supportability, producibility, and testability. The use of multi-disciplinary teams is the approach that both DoD and industry increasingly have taken to achieve integrated designs. Teams have been found to facilitate meeting cost, performance, and other objectives from product concept through disposal.

The use of multi-disciplinary teams in design is known as Integrated Product and Process Development, simultaneous engineering, concurrent engineering, Integrated Product Development, Design-Build, and other proprietary and non-proprietary names expressing the same concept. (The DoD use of the term Integrated Product and Process Development (IPPD) is a wider concept that includes the systems engineering effort as an element. The DoD policy is explained later in this chapter.) Whatever name is used, the fundamental idea involves multi-functional, integrated teams (preferably co-located), that jointly derive requirements and schedules that place equal emphasis on product and process development. The integration requires:

- Inclusion of the eight primary functions in the team(s) involved in the design process,
- Technical process specialties such as quality, risk management, safety, etc., and
- Business processes (usually in an advisory capacity) such as, finance, legal, contracts, and other non-technical support.

Benefits

The expected benefits from team-based integration include:

- Reduced rework in design, manufacturing, planning, tooling, etc.,
- Improved first time quality and reduction of product variability,
- Reduced cost and cycle time,
- Reduced risk,
- Improved operation and support, and
- General improvement in customer satisfaction and product quality throughout its life cycle.

Characteristics

The key attributes that characterize a well integrated effort include:

- Customer focus,
- Concurrent development of products and processes,
- Early and continuous life cycle planning,
- Maximum flexibility for optimization,
- Robust design and improved process capability,
- Event-driven scheduling,
- Multi-disciplinary teamwork,

- Empowerment,
- Seamless management tools, and
- Proactive identification and management of risk.

Organizing for System Development

Most DoD program offices are part of a Program Executive Office (PEO) organization that is usually supported by a functional organization, such as a systems command. Contractors and other government activities provide additional necessary support. Establishing a system development organization requires a network of teams that draw from all these organizations. This network, sometimes referred to as the enterprise, represents the interests of all the stakeholders and provides vertical and horizontal communications.

These integrated teams are structured using the WBS and designed to provide the maximum

vertical and horizontal communication during the development process. Figure 18-1 shows how team structuring is usually done. At the system level there is usually a management team and a design team. The management team would normally consist of the government and contractor program managers, the deputy program manager(s), possibly the contractor Chief Executive Officer, the contracting officer, major advisors picked by the program manager, the system design team leader, and other key members of the system design team. The design team usually consists of the first-level subsystem and life-cycle integrated team leaders.

The next level of teams is illustrated on Figure 18-1 as either product or process teams. These teams are responsible for designing system segments (product teams) or designing the supporting or enabling products (process teams). At this level the process teams are coordinating the system level process development. For example, the support team will integrate the supportability analysis from the parts being generated in lower-level design and

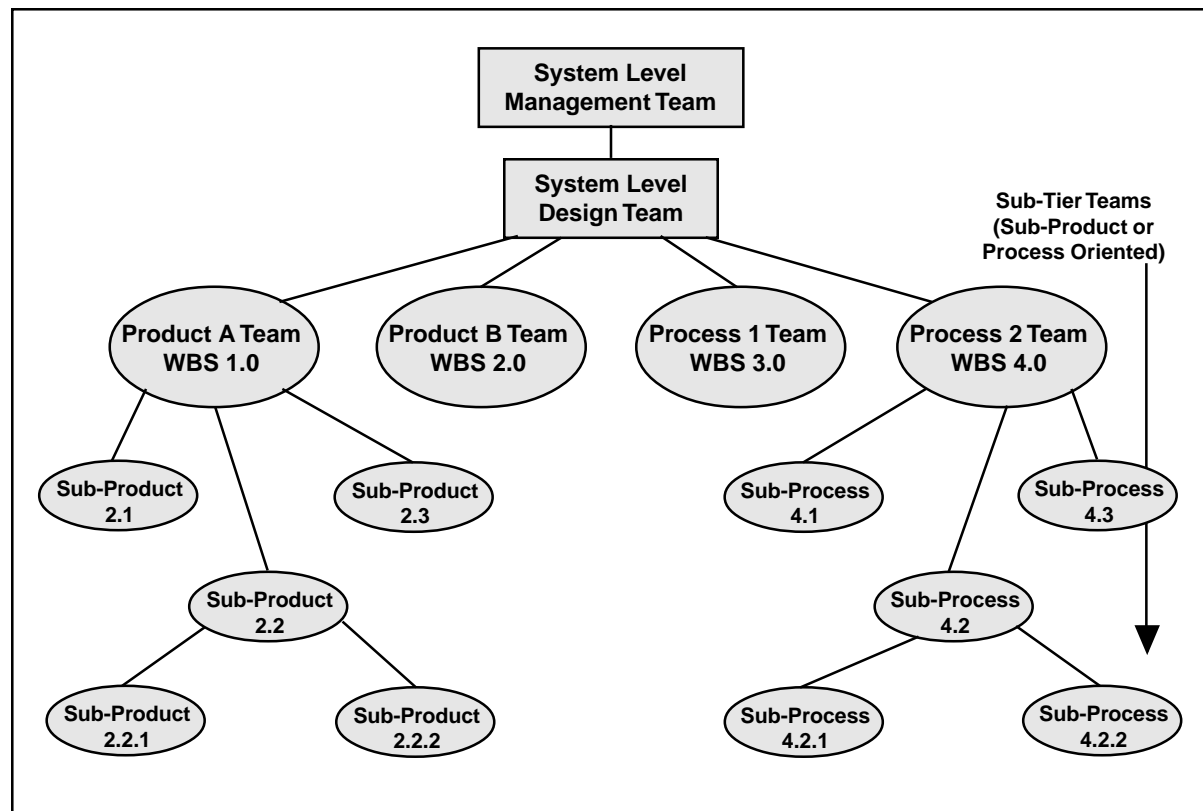


Figure 18-1. Integrated Team Structure

support process teams. Teams below this level continue the process at a lower level of decomposition. Teams are formed only to the lowest level necessary to control the integration. DoD team structures rarely extend lower than levels three or four on the WBS, while contractor teams may extend to lower levels, depending on the complexities of the project and the approach favored by management.

The team structure shown by Figure 18-1 is a hierarchy that allows continuous vertical communication. This is achieved primarily by having the team leaders, and, if appropriate, other key members of a team, be team members of the next highest team. In this manner the decisions of the higher team is immediately distributed and explained to the next team level, and the decisions of the lower teams are presented to the higher team on a regular basis. Through this method decisions of lower-level teams follow the decision making of higher teams, and the higher-level teams'

decisions incorporate the concerns of lower-level teams.

The normal method to obtain horizontal communication is shown in Figure 18-2. At least one team member from the Product A Team is also a member of the Integration and Test Team. This member would have a good general knowledge of both testing and Product A. The member's job would be to assist the two teams in designing their end or enabling products, and in making each understand how their decisions would impact the other team. Similarly, the member that sits on both Product A and B teams would have to understand the both technology and the interface issues associated with both items.

The above is an idealized case. Each type of system, each type of contractor organization, and each level of available resources requires a tailoring of this structure. With each phase the focus and the tasks change and so should the structure. As phases

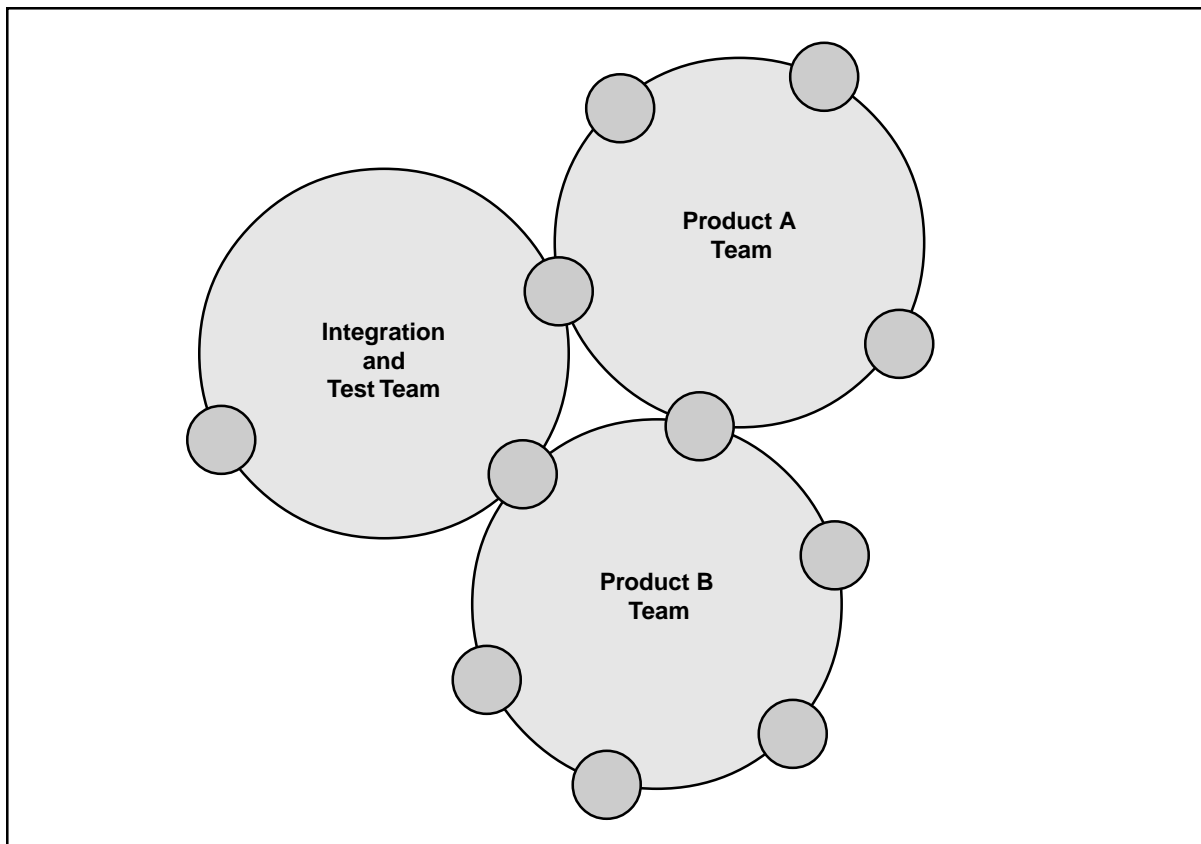


Figure 18-2. Cross Membership

are transited, the enterprise structure and team membership should be re-evaluated and updated.

18.2 INTEGRATED TEAMS

Integrated teams are composed of representatives from all appropriate primary functional disciplines working together with a team leader to:

- Design successful and balanced products,
- Develop the configuration for successful life-cycle control,
- Identify and resolve issues, and
- Make sound and timely decisions.

The teams follow the disciplined approach of the systems engineering process starting with requirements analysis through to the development of configuration baselines as explained earlier in this book. The system-level design team should be responsible for systems engineering management planning and execution. The system-level management team, the highest level program IPT, is responsible for acquisition planning, resource allocation, and management. Lower-level teams are responsible for planning and executing their own processes.

Team Organization

Good teams do not just happen; they are the result of calculated management decisions and actions. Concurrent with development of the enterprise organization discussed above, each team must also be developed. Basically the following are key considerations in planning for a team within an enterprise network:

- The team must have appropriate representation from the primary functions, technical specialties, and business support,
- There must be links to establish vertical and horizontal communication in the enterprise,

- You should limit over-uses of cross membership. Limit membership on three or four teams as a rough rule of thumb for the working level, and
- Ensure appropriate representation of government, contractor, and vendors to assure integration across key organizations.

Team Development

When teams are formed they go through a series of phases before a synergistic self-actuating team is evolved. These phases are commonly referred to as forming, storming, norming and performing. The timing and intensity of each phase will depend on the team size, membership personality, effectiveness of the team building methods employed, and team leadership. The team leaders and an enterprise-level facilitator provide leadership during the team development.

Forming is the phase where the members are introduced to their responsibilities and other members. During this period members will tend to need a structured situation with clarity of purpose and process. If members are directed during this initial phase, their uncertainty and therefore apprehension is reduced. Facilitators controlling the team building should give the members rules and tasks, but gradually reduce the level of direction as the team members begin to relate to each other. As members become more familiar with other members, the rules, and tasks, they become more comfortable in their environment and begin to interact at a higher level.

This starts the storming phase. *Storming* is the conflict brought about by interaction relating to the individuals' manner of dealing with the team tasks and personalities. Its outcome is members who understand the way they have to act with other members to accomplish team objectives. The dynamics of storming can be very complex and intense, making it the critical phase. Some teams will go through it quickly without a visible ripple, others will be loud and hot, and some will never emerge from this phase. The team building facilitators must be alert to dysfunctional activity.

Members may need to be removed or teams reorganized. Facilitators during this period must act as coaches, directing but in a personal collaborative way. They should also be alert for members that are avoiding storming, because the team will not mature if there are members who are not personally committed to participate in it.

Once the team has learned to interact effectively it begins to shape its own processes and become more effective in joint tasks. It is not unusual to see some reoccurrence of storming, but if the storming phase was properly transitioned these incidences should be minor and easily passed. In this phase, *norming*, the team building facilitators become a facilitator to the team—not directing, but asking penetrating questions to focus the members. They also monitor the teams and correct emerging problems.

As the team continues to work together on their focused tasks, their performance improves until they reach a level of self-actuation and quality decision making. This phase, *performing*, can take a while to reach, 18 months to two years for a system-level design team would not be uncommon. During the performing stage, the team building facilitator monitors the teams and corrects emerging problems.

At the start of a project or program effort, team building is commonly done on an enterprise basis with all teams brought together in a team-building exercise. There are two general approaches to the exercise:

- A team-learning process where individuals are given short but focused tasks that emphasize group decision, trust, and the advantages of diversity.
- A group work-related task that is important but achievable, such as a group determination of the enterprise processes, including identifying and removing non-value added traditional processes.

Usually these exercises allow the enterprise to pass through most of the storming phase if done

correctly. Three weeks to a month is reasonable for this process, if the members are in the same location. Proximity does matter and the team building and later team performance are typically better if the teams are co-located.

18.3 TEAM MAINTENANCE

Teams can be extremely effective, but they can be fragile. The maintenance of the team structure is related to empowerment, team membership issues, and leadership.

Empowerment

The term empowerment relates to how responsibilities and authority is distributed throughout the enterprise. Maintenance of empowerment is important to promote member ownership of the development process. If members do not have personal ownership of the process, the effectiveness of the team approach is reduced or even neutralized. The quickest way to destroy participant ownership is to direct, or even worse, overturn solutions that are properly the responsibility of the team. The team begins to see that the responsibility for decisions is at a higher level rather than at their level, and their responsibility is to follow orders, not solve problems.

Empowerment requires:

- The flow of authority through the hierarchy of teams, not through personal direction (irrespective of organizational position). Teams should have clear tasking and boundaries established by the higher-level teams.
- Responsibility for decision making to be appropriate for the level of team activity. This requires management and higher-level teams to be specific, clear, complete, and comprehensive in establishing focus and tasking, and in specifying what decisions must be coordinated with higher levels. They should then avoid imposing or overturning decisions more properly in the realm of a lower level.

- Teams at each level be given a clear understanding of their duties and constraints. Within the bounds of those constraints and assigned duties members should have autonomy. Higher-level teams and management either accept their decisions, or renegotiate the understanding of the task.

Membership Issues

Another maintenance item of import is team member turnover. Rotation of members is a fact of life, and a necessary process to avoid teams becoming too closed. However, if the team has too fast a turnover, or new members are not fully assimilated, the team performance level will decline and possibly revert to storming. The induction process should be a team responsibility that includes the immediate use of the new team member in a jointly performed, short term, easily achievable, but important task.

Teams are responsible for their own performance, and therefore should have significant, say over the choice of new members. In addition teams should have the power to remove a member; however, this should be preceded by identification of the problem and active intervention by the facilitator. Removal should be a last resort.

Awards for performance should, where possible, be given to the team rather than individuals (or equally to all individuals on the team). This achieves several things: it establishes a team focus, shows recognition of the team as a cohesive force, recognizes that the quality of individual effort is at least in part due to team influence, reinforces the membership's dedication to team objectives, and avoids team member segregation due to uneven awards. Some variation on this theme is appropriate where different members belong to different organizations, and a common award system does not exist. The system-level management team should address this issue, and where possible assure equitable awards are given team members. A very real constraint on cash awards in DoD rises in the case of teams that include both civilian and military members. Military members cannot be given

cash awards, while civilians can. Con-sequently, managers must actively seek ways to reward all team members appropriately, leaving no group out at the expense of others.

Leadership

Leadership is provided primarily by the organizational authority responsible for the program, the enterprise facilitator, and the team leaders. In a DoD program, the organizational leaders are usually the program manager and contractor senior manager. These leaders set the tone of the enterprise adherence to empowerment, the focus of the technical effort, and the team leadership of the system management team. These leaders are responsible to see that the team environment is maintained. They should coordinate their action closely with the facilitator.

Facilitators

Enterprises that have at least one facilitator find that team and enterprise performance is easier to maintain. The facilitator guides the enterprise through the team building process, monitors the team network through metrics and other feedback, and makes necessary corrections through facilitation. The facilitator position can be:

- A separate position in the contractor organization,
- Part of the responsibilities of the government systems engineer or contractor project manager, or
- Any responsible position in the first level below the above that is related to risk management.

Obviously the most effective position would be one that allows the facilitator to concentrate on the teams' performance. Enterprise level facilitators should have advanced facilitator training and (recommended) at least a year of mentored experience. Facilitators should also have significant broad experience in the technical area related to the development.

Team Leaders

The team leaders are essential for providing and guiding the team focus, providing vertical communication to the next level, and monitoring the team's performance. Team leaders must have a clear picture of what constitutes good performance for their team. They are not supervisors, though in some organizations they may have supervisory administrative duties. The leader's primary purpose is to assure that the environment is present that allows the team to perform at its optimum level—not to direct or supervise.

The team leader's role includes several difficult responsibilities:

- Taking on the role of coach as the team forms,
- Facilitating as the team becomes self-sustaining,
- Sometimes serving as director (only when a team has failed, needs refocus or correction, and is done with the facilitator),
- Providing education and training for members,
- Facilitating team learning,
- Representing the team to upper management and the next higher-level team, and
- Facilitating team disputes.

Team leaders should be trained in basic facilitator principles. This training can be done in about a week, and there are numerous training facilities or companies that can offer it.

18.4 TEAM PROCESSES

Teams develop their processes from the principles of system engineering management as presented earlier in the book. The output of the teams is the design documentation associated with products identified on the system architecture, including both end product components and enabling products.

Teams use several tools to enhance their productivity and improve communication among enterprise members. Some examples are:

- Constructive modeling (CAD/CAE/CAM/CASE) to enhance design understanding and control,
- Trade-off studies and prioritization,
- Event-driven schedules,
- Prototyping,
- Metrics, and most of all
- Integrated membership that represents the life cycle stakeholders.

Integrated Team Rules

The following is a set of general rules that should guide the activities and priorities of teams in a system design environment:

- Design results must be communicated clearly, effectively, and timely.
- Design results must be compatible with initially defined requirements.
- Continuous “up-the-line” communication must be institutionalized.
- Each member needs to be familiar with all system requirements.
- Everyone involved in the team must work from the same database.
- Only one member of the team has the authority to make changes to one set of master documentation.
- All members have the same level of authority (one person, one vote).
- Team participation is consistent, success-oriented, and proactive.

- Team discussions are open with no secrets.
- Team member disagreements must be reasoned disagreement (alternative plan of action versus unyielding opposition).
- Trade studies and other analysis techniques are used to resolve issues.
- Issues are raised and resolved early.
- Complaints about the team are not voiced outside the team. Conflicts must be resolved internally.

Guidelines for Meeting Management

Even if a team is co-located as a work unit, regular meetings will be necessary. These meetings and their proper running become even more important if the team is not co-located and the meeting is the primary means of one-on-one contact. A well-run technical meeting should incorporate the following considerations:

- Meetings should be held only for a specific purpose and a projected duration should be targeted.
- Advance notice of meetings should normally be at least two weeks to allow preparation and communication between members.
- Agendas, including time allocations for topics and supportive material should be distributed no less than three business days before the team meeting. The objective of the meeting should be clearly defined.
- Stick to the agenda during the meeting. Then cover new business. Then review action items.
- Meeting summaries should record attendance, document any decision or agreements reached, document action items and associated due-dates, provide a draft agenda for the next meeting, and frame issues for higher-level resolution.

- Draft meeting summaries should be provided to members within one working day of the meeting. A final summary should be issued within two working days after the draft comments deadline.

18.5 BARRIERS TO INTEGRATION

There are numerous barriers to building and maintaining a well functioning team organization, and they are difficult to overcome. Any one of these barriers can negate the effectiveness of an integrated development approach. Common barriers include:

- Lack of top management support,
- Team members not empowered,
- Lack of access to a common database,
- Lack of commitment to a cultural change,
- Functional organization not fully integrated into a team process,
- Lack of planning for team effort,
- Staffing requirements conflict with teams,
- Team members not collocated,
- Insufficient team education and training,
- Lessons learned and successful practices not shared across teams,
- Inequality of team members,
- Lack of commitment based on perceived uncertainty,
- Inadequate resources, and
- Lack of required expertise on either the part of the contractor or government.

Breaking Barriers

Common methods to combat barriers include:

- Education and training, and then more education and training: it breaks down the uncertainty of change, and provides a vision and method for success.
- Use a facilitator not only to build and maintain teams, but also to observe and advise management.
- Obtain management support up front. Management must show leadership by managing the teams' environment rather than trying to manage people.
- Use a common database open to all enterprise members.
- Establish a network of teams that integrates the design and provides horizontal and vertical communication.
- Establish a network that does not over-tax available resources. Where a competence is not available in the associated organizations, hire it through a support contractor.

- Where co-location is not possible have regular working sessions of several days duration. Telecommunications, video conferencing, and other technology based techniques can also go far to alleviate the problems of non-collocation.

Summary Comments

- Integrating system development is a systems engineering approach that integrates all essential primary function activities through the use of multi-disciplinary teams, to optimize the design, manufacturing and supportability processes.
- Team building goes through four phases: forming, storming, norming, and performing.
- Key leadership positions in a program network of teams are the program manager, facilitator, and team leaders.
- A team organization is difficult to build and maintain. It requires management attention and commitment over the duration of the teams involved.

SUPPLEMENT 18-A

IPPD – A DOD MANAGEMENT PROCESS

The DoD policy of Integrated Product and Process Development (IPPD) is a broad view of integrated system development which includes not only systems engineering, but other areas involved in formal decision making related to system development. DoD policy emphasizes integrated management at and above the Program Manager (PM) level. It requires IPPD at the systems engineering level, but does not direct specific organizational structures or procedures in recognition of the need to design a tailored IPPD process to every individual situation.

Integrated Product Teams

One of the key IPPD tenets is multi-disciplinary integration and teamwork achieved through the use of Integrated Product Teams (IPTs). While IPTs may not be the best solution for every management situation, the requirement to produce integrated designs that give consideration to a wide array of technical and business concerns leads most organizations to conclude that IPTs are the best organizational approach to systems management. PMs should remember that the participation of a contractor or a prospective contractor on a IPT should be in accordance with statutory requirements, such as procurement integrity rules. The service component's legal advisor must review prospective contractor involvement on IPTs. To illustrate issues the government-contractor team arrangement raises, the text box at the end of this section lists nine rules developed for government members of the Advanced Amphibious Assault Vehicle (AAAV) design IPTs.

The Secretary of Defense has directed that DoD perform oversight and review by using IPTs. These IPTs function in a spirit of teamwork with

participants empowered and authorized, to the maximum extent possible, to make commitments for the organization or the functional area they represent. IPTs are composed of representatives from all appropriate functional disciplines working together to build successful programs and enabling decision makers to make the right decisions at the right time.

DoD IPT Structure

The DoD oversight function is accomplished through a hierarchy of teams that include levels of management from DoD to the program level. There are three basic levels of IPTs: the Overarching IPT (OIPT), the Working IPTs (WIPT), and Program IPTs with the focus and responsibilities as shown by Figure 18-3. For each ACAT I program, there will be an OIPT and at least one WIPT. WIPTs will be developed for particular functional topics, e.g., test, cost/performance, contracting, etc. An Integrating IPT (IIPT) will coordinate WIPT efforts and cover all topics not otherwise assigned to another IPT. These teams are structurally organized as shown on Figure 18-4.

Overarching IPT (OIPT)

The OIPT is a DoD level team whose primary responsibility is to advise the Defense Acquisition Executive on issues related to programs managed at that level. The OIPT membership is made up of the principals that are charged with responsibility for the many functional offices at the Office of the Secretary of Defense (OSD).

The OIPT provides:

- Top-level strategic guidance,

Organization	Teams	Focus	Participant Responsibilities
OSD and Components	OIPT*	<ul style="list-style-type: none"> • Strategic Guidance • Tailoring • Program Assessment • Resolve Issues Elevated by WIPTs 	<ul style="list-style-type: none"> • Program Success • Functional Area Leadership • Independent Assessment • Issue Resolution
	WIPTs*	<ul style="list-style-type: none"> • Planning for Program Success • Opportunities for Acquisition Reform (e.g. innovation, streamlining) • Identify/Resolve Program Issues • Program Status 	<ul style="list-style-type: none"> • Functional Knowledge and Experience • Empowered Contribution • Recom.'s for Program Success • Communicate Status and Unresolved Issues
Program Teams and System Contractors	Program IPTs**	<ul style="list-style-type: none"> • Program Execution • Identify and Implement Acquisition Reform 	<ul style="list-style-type: none"> • Manage Complete Scope of Program Resources, and Risk • Integrate Government and Contractor Efforts for Report Program Status and Issues
<p>* Covered in "Rules of the Road"</p> <p>** Covered in "Guide to Implementation and Management of IPPD in DoD Acquisition"</p>			

Figure 18-3. Focus and Responsibilities of IPTs

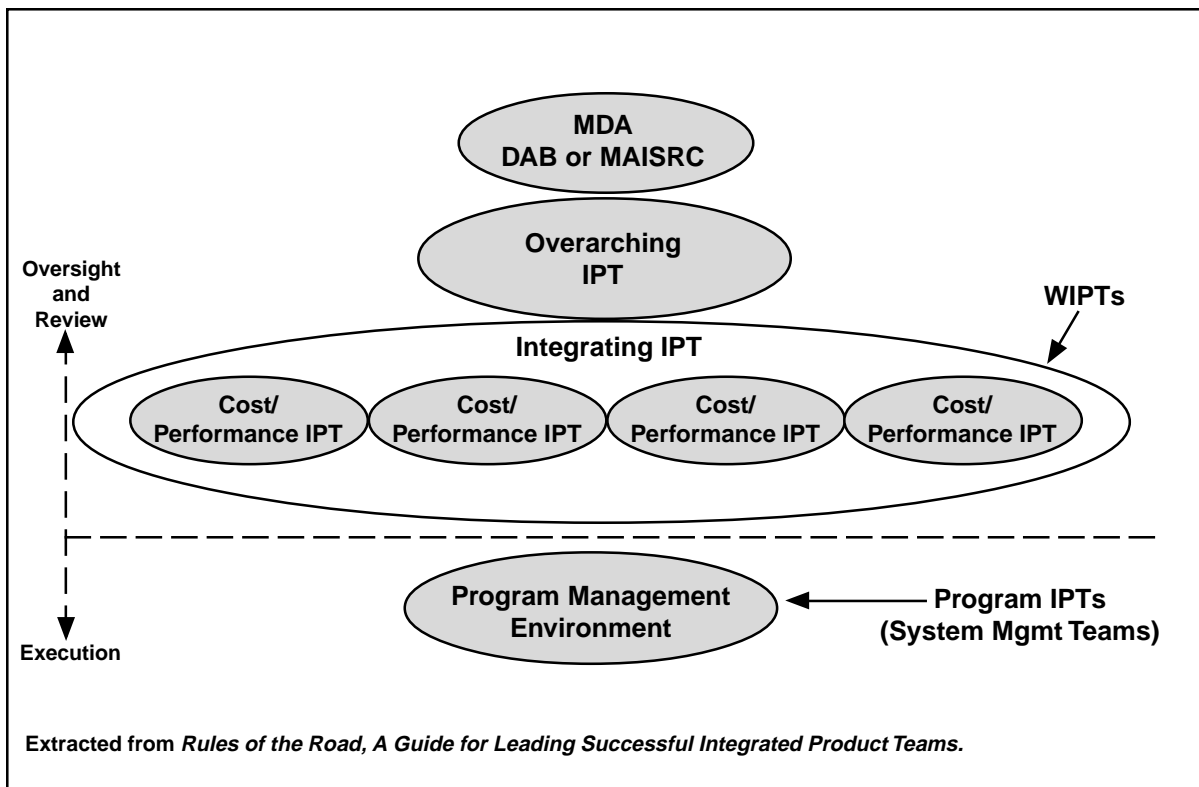


Figure 18-4. IPT Structure

- Functional area leadership,
- Forum for issue resolution,
- Independent assessment to the MDA,
- Determine decision information for next milestone review, and
- Provide approval of the WIPT structures and resources.
- Proposing tailored document and milestone requirements,
- Reviewing and providing early input to documents,
- Coordinating WIPT activities with the OIPT members,
- Resolving or evaluating issues in a timely manner, and

Working-Level IPT (WIPT)

The WIPTs may be thought of as teams that link the PM to the OIPT. WIPTs are typically functionally specialized teams (test, cost-performance, etc.). The PM is the designated head of the WIPT, and membership typically includes representation from various levels from the program to OSD staff. The principal functions of the WIPT are to advise the PM in the area of specialization and to advise the OIPT of program status.

The duties of the WIPT include:

- Assisting the PM in developing strategies and in program planning, as requested by the PM,
- Establishing IPT plan of action and milestones,

- Obtaining principals' concurrence with applicable documents or portions of documents.

Program IPTs

Program IPTs are teams that perform the program tasks. The integration of contractors with the government on issues relative to a given program truly occurs at the program IPT level. The development teams (product and process teams) described earlier in this chapter would be considered program IPTs. Program IPTs would also include teams formed for business reasons, for example teams established to prepare Planning, Programming, and Budgeting System (PPBS) documentation, to prepare for Milestone Approval, to develop the RFP, or the like.

SUPPLEMENT 18-B

GOVERNMENT ROLE ON IPTs

The following list was developed by the Advanced Amphibious Assault Vehicle (AAAV) program to inform its government personnel of their role on contractor/government integrated teams. It addresses government responsibilities and the realities imposed by contractual and legal constraints. Though it is specific to the AAAV case, it can be used as guidance in the development of team planning for other programs.

1. The IPTs are contractor-run entities. We do not lead or manage the IPTs.
2. We serve as “customer” representatives on the IPTs. We are there to **REDUCE THE CYCLE TIME** of contractor-Government (customer) communication. In other words, we facilitate contractor personnel getting Government input faster. Government IPT members also enable us to provide the contractor IPT Status and issue information up the Government chain on a daily basis (instead of monthly or quarterly).
3. **WE DO NOT DO** the contractor’s IPT WORK, or any portion of their work or tasks. The contractor has been contracted to perform the tasks outlined in the contract SOW; their personnel and their subcontractors’ personnel will perform those tasks, not us. But Government IPT members will be an active part of the deliberations during the development of, and participate in “on-the-fly” reviews of deliverables called out in CDRLs.
4. When asked by contractor personnel for the Government’s position or interpretation, Government IPT members can offer their personal opinion, as an IPT member, or offer expert opinion; you can provide guidance as to our “customer” opinion and what might be acceptable to the Government but you can only offer the “Government” position for items that have been agreed to by you and your Supervisor. **IT IS UP TO YOUR SUPERVISORS TO EMPOWER EACH OF YOU TO AN APPROPRIATE LEVEL OF AUTHORITY.** It is expected that this will start at a minimal level of authority and be expanded as each individual’s IPT experience and program knowledge grows. However... (see items 5 and 6).
5. Government IPT members **CAN NOT** authorize any changes or deviations to/from the contract SOW or Specifications. Government IPT members can participate in the deliberations and discussions that would result in the suggestion of such changes. If/When an IPT concludes that the best course of action is not in accordance with the contract, and a contract change is in order, then the contractor must submit a Contract Change Request (CCR) through normal channels.
6. Government IPT members **CAN NOT** authorize the contractor to perform work that is in addition to the SOW/contract requirements. The contractor IPTs can perform work that is not specifically required by the contract, at their discretion (provided they stay within the resources as identified in the Team Operating Contract (TOC)).
7. Government IPT member participation in contractor IPT activities **IS NOT** Government consent that the work is approved by the Government or is chargeable to the contract. If an IPT is doing something questionable, identify it to your supervisor or Program Management Team (PMT) member.

8. Government members of IPTs do not approve or disapprove of IPT decisions, plans, or reports. You offer your opinion in their development, you vote as a member, and you coordinate issues with your Supervisor and bring the “Government” opinion (in the form of your opinion) back to the IPT, with the goal of improving the quality of the products; you don’t have veto power.
9. Government IPT members are still subject to all the Government laws and regulations regarding “directed changes,” ethics, and conduct. Your primary function is to perform those functions that are best done by Government employees, such as:
 - Conveying to contractor personnel your knowledge/expertise on Marine Corps operations and maintenance techniques;
 - Interfacing with all other Government organizations (e.g., T&E);
 - Control/facilitization of government furnished equipment and materials (GFE and GFM);
 - Ensuring timely payment of submitted vouchers; and
 - Full participation in Risk Management.